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Working memory and general intelligence: The role of short-term storage

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Abstract

This study examined the relationships among short-term memory (STM), working memory (WM), and general intelligence (*g*). Two independent samples of participants performed several verbal, quantitative, and spatial STM and WM tasks, as well as a broad set of tests measuring psychometric intelligence. The constructs are carefully sampled to include heterogeneous tasks and tests to control the effect of unwanted variance. The results have several points of interest. First, there is a strong correlation between STM and WM. Second, WM is a slightly better predictor of *g* than STM. Third, when the correlation between STM and WM is statistically controlled, the unique predictive power of WM is small, which suggests that the short-term storage component of the WM system largely drives the relationship between WM and *g*.

Keywords: Memory span tasks; Short-term memory; Working memory; General intelligence

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1. Introduction

The relationship between working memory (WM) and intelligence is broadly documented (Ackerman, Beier, & Boyle, 2005). Several studies have considered the relationship between WM and an array of cognitive abilities: general intelligence or *g* (Ackerman, Beier, & Boyle, 2002; Colom, Abad, Rebollo, & Shih, in press; Colom, Rebollo, Palacios, Juan-Espinosa, & Kyllonen, 2004; Colom & Shih, 2004; Süß, Oberauer, Wittman, Wilhelm, & Schulze, 2002), reasoning ability (Kyllonen & Christal, 1990), fluid intelligence (Bayliss, Jarrold, Gunn, & Baddeley, 2003; Colom, Flores-Mendoza, & Rebollo, 2003; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Engle, Kane, & Tuholski, 1999; Kane et al., 2004), spatial ability (Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001), and reading comprehension (Daneman & Merikle, 1996). However, the causes underlying the relationship between these constructs remain mysterious.

WM tasks rely on the temporary maintenance of any given information while performing some kind of concurrent processing. For instance, the reading span task requires the reading of several unrelated sentences and the temporary maintenance of the last word of each sentence for later recall (Daneman & Carpenter, 1980). Presumably, those WM tasks are different from traditional short-term memory (STM) tasks, because the latter simply require the temporary maintenance of several pieces of information without any explicit concurrent processing requirement.

Researchers have tried to answer the question of what make WM tasks predictors of performance on cognitive ability measures. Daneman and Carpenter (1980) proposed the widely known resource sharing model. Such a model postulates the existence of a trade-off between the storage and processing demands, WM tasks measure a functional capacity of resources that can be allocated between the storage and processing activities (Daneman & Hannon, 2001; Just & Carpenter, 1992; Turner & Engle, 1989). However, Engle et al. (1999) claimed that WM capacity is determined by STM capacity plus a so-called controlled attention ability. This ability is conceived as a domain-general limited attentional capacity for performing controlled processing or sustaining focus on task-relevant information in the face of interfering or distracting stimuli. Interestingly, this model proposes that variance shared between WM and STM tasks should reflect their common short-term storage component, whereas the residual WM variance should reflect the controlled attention or executive component of the WM system.

Engle et al. (1999) have proposed that individual differences on measures of WM capacity *primarily* reflect differences in controlled-attention capability. The factor underlying measures of WM and higher level cognitive tasks (like performance on conventional intelligence tests) is the ability to maintain a representation active in the face of interference from automatically activated representations competing for selection for action and in the face of distractions that would otherwise draw attention away from the currently needed representation.

However, existing evidence indicates that the relation between WM and intelligence is not so different from the relation between STM and intelligence. Mukunda and Hall's (1992) meta-analysis included articles published between 1976 and 1989. They distinguished WM and STM tasks, finding that the raw relationship between STM and intelligence was .26, whereas the raw relationship between WM and intelligence was .28. Ackerman et al. (2005) conducted a meta-analysis examining the relationship between WM and intelligence, as well as between STM and intelligence. This study was based on studies published from 1872 to 2002. The meta-analytically